National Aeronautics and Space Administration

EVA Systems, Robotic Systems and Simulation

presentation to the

Asteroid Initiative Idea Synthesis Workshop

NASA's Goddard Space Flight Center

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ARM Challenges

- This mission is incredibly difficult
  - This is both good and bad
- Some significant challenges are:
  - Small targets are hard to find and characterize
  - Capture technologies difficult to prove on the ground
  - Mass, mass, mass
  - Signal latency due to target location
  - Limited EVA time

- Focus areas of this talk
  - Robotics during capture and EVA
  - Dexterous tools – both EVA and robotic
  - Simulation systems

…and, by the way, make the solution extensible for the future.

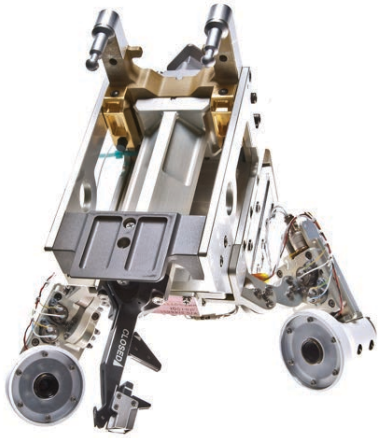
Robotic Arm and Tool Drive System

- Facilitates “multiple dissimilar technologies” for capture
- Characterizes asteroid prior to crew launch
  - Allows for proper training/tools to accommodate asteroid composition
- Enables “get-ahead” work prior to crew arrival
  - Asteroid fragmenting, and coring (significant increase in exploration/science return)
- Augments EVA crew member efficiency
  - Installs/acts as crew aids
  - Robotic translation aid

- Present flight arm development effort is ~ one year from receipt of engineering development unit with control electronics
  - Deep-space flight qualification heritage from Mars Exploration Program rovers
  - GEO designed arm developed for DARPA’s FREND program
- Tool drive system allows tool swap and actuation of tools
- Software automatically handles:
  - Control of Cartesian motion of tool position/orientation
  - Avoiding singularities
  - Observing workspace and joint limits
  - Avoiding collision
  - Currently in integration and test on ground robot platforms

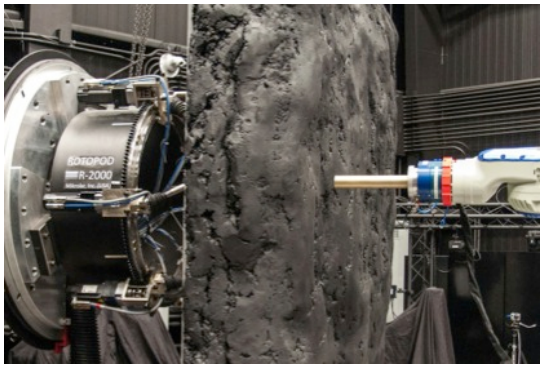
Dexterous Tools - Both EVA and Robotic

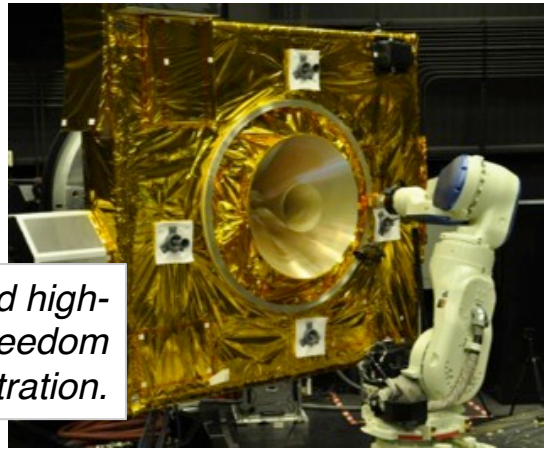
- Asteroid material handling is an unstructured problem necessitating a wide range of tools and techniques
- The Satellite Servicing Capabilities Office has repeatedly demonstrated its capacity for assessment of a specialized EVA task, and answered the call with the design and build of tools and devices for astronauts to utilize in completing intricate operations
  - Over 300 unique tools flown as part of the Hubble Servicing Missions
  - The Robotic Refueling Mission has continued to further tool development
  - Our partner West Virginia University has produced ‘smart’ gripper tool and now is leveraging mining tool technology
- EVA tasks developed around multifunctional tools will serve to meet conflicting requirements of robust solutions with constrained mass budgets



Simulation Systems (1 of 2)
Satellite Technology Center at NASA GSFC

- Motion platforms with validated real-time, flexible modes simulating relative satellite dynamics
- "One-touch," software-based reconfigurable simulation of inertias, physical properties, kinematics, and dynamics of various space robots and targets
- Used to support:
  - Sensor performance envelope determination
  - Engineering trade studies and requirement development and verification
  - Teleoperation and autonomous operations
    - Flight tool engineering development and testing
    - Procedure development
    - Operator training

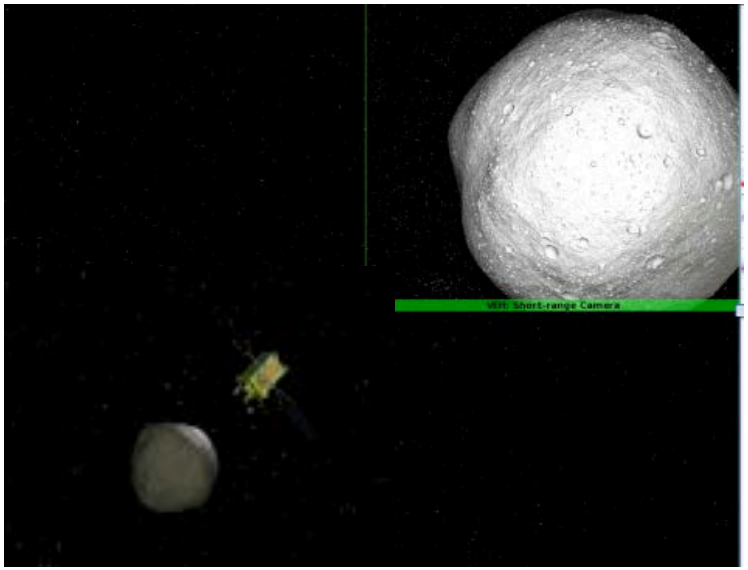




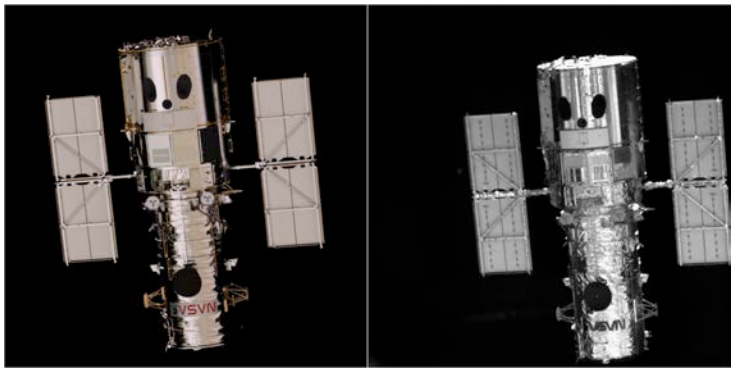
March 2013: NASA performs a first-of-its-kind high-fidelity, near real-time, full 6-degree-of-freedom autonomous capture demonstration.

Simulation Systems (2 of 2)
Freespace

- Freespace is a collection of software tools enabling:
  - Multibody Dynamic Simulation validated against industry applications
    - High-end graphics visualization (real-time shadowing, reflections, terrain generation)
    - Matlab-like console interface for simulation setup and analysis
    - Shared library of sensors, actuators, control methods, targeting methods or isolated project specific modules



- Geomod modeling tool tied in with Freespace simulations
  - Visualize trajectories, import Earth, Sun, satellite CAD models
  - Modify material parameters, groupings, locations, etc.



Synthetic *Actual – STS-125*

Eager To Continue the Agency's EVA History